

## WHAT IS CLAIMED IS:

1        1.    An apparatus for detecting a boundary in a vector  
2    sequence representing a signal, said apparatus comprising:

3        a boundary detection controller capable of detecting a  
4    boundary in a vector sequence  $\vec{A}(n)$  having an arbitrary dimension by  
5    selecting a function to represent a modified first order difference  
6    vector of said vector sequence  $\vec{A}(n)$ , denoted  $MFD(\vec{A}(n))$ , wherein  
7    said function is dependent upon a frequency characteristic of said  
8    vector sequence  $\vec{A}(n)$ ;

9        wherein said boundary detection controller is capable of  
10    operating upon said modified first order difference vector  
11     $MFD(\vec{A}(n))$  with a length operator to obtain a scalar value  
12     $\|MFD(\vec{A}(n))\|$  that represents a value of a change in said vector  
13    sequence  $\vec{A}(n)$  at point  $n$  and detecting a local maximum of said  
14    scalar value  $\|MFD(\vec{A}(n))\|$ ; and

15        wherein said boundary detection controller is capable of  
16    determining whether said local maximum of said scalar value  
17     $\|MFD(\vec{A}(n))\|$  is larger than a predetermined threshold value.

1           2.    An apparatus for detecting a boundary in a vector  
2   sequence representing a signal as set forth in Claim 1 wherein said  
3   boundary detection controller is capable of selecting point  $n$  as an  
4   edge point of  $\vec{A}(n)$  when said local maximum of said scalar value  
5    $\|MFD(\vec{A}(n))\|$  is larger than said predetermined threshold value.

1           3.    An apparatus for detecting a boundary in a vector  
2   sequence representing a signal as set forth in Claim 1 wherein said  
3   vector sequence  $\vec{A}(n)$  is in Euclidean space and said length operator  
4   has the form:

$$\|\vec{A}(n)\| = \sqrt{a_1^2(n) + a_2^2(n) + \dots + a_p^2(n)}.$$

1           4.    An apparatus for detecting a boundary in a vector  
2   sequence as claimed in Claim 2 wherein said boundary detection  
3   controller is capable of locating a boundary between two neighbor  
4   integers,  $n$  and  $n-1$ , by locating a zero crossing of a difference of  
5   a length of said modified first order difference vector for  $\vec{A}(n)$ ,  
6   denoted  $DLMFD(\vec{A}(n))$ , where said difference of a length of said  
7   modified first order difference vector is calculated by subtracting  
8   an absolute value of said scalar value  $\|MFD(\vec{A}(n-1))\|$  from an

9 absolute value of said scalar value  $\|MFD(\vec{A}(n+1))\|$ .

1        5. An apparatus for detecting a boundary in a vector  
 2 sequence as claimed in Claim 4 wherein said boundary detection  
 3 controller is capable of locating said zero crossing of a  
 4 difference of a length of said modified first order difference  
 5 vector for  $\vec{A}(n)$  by calculating said location of said boundary  
 6 between said two neighbor integers,  $n$  and  $n-1$ , using the  
 7 expression:

$$8 \quad t_0 = \frac{|DLMFD(\vec{A}(n-1))|}{|DLMFD(\vec{A}(n-1))| + |DLMFD(\vec{A}(n))|} + n - 1$$

9 where  $t_0$  represents a location of said boundary, and where  $n$   
 10 represents a value of said integer  $n$ , and where  $|DLMFD \vec{A}((n))|$   
 11 represents an absolute value of a difference of a length of a  
 12 modified first order difference of said vector sequence  $\vec{A}(n)$  at a  
 13 location of said integer  $n$ , and where  $|DLMFD \vec{A}((n-1))|$  represents an  
 14 absolute value of a difference of a length of a modified first  
 15 order difference of said vector sequence  $\vec{A}(n)$  at a location of said  
 16 integer  $n-1$ .

6. An apparatus for detecting an edge in a vector space  $(Y, U, V)$  of a color image signal as set forth in Claim 1, where  $Y$  represents a luminance signal, and where  $U$  and  $V$  represent chrominance signals, and where said  $Y$ ,  $U$ , and  $V$  signals have an equal normalized bandwidth, said apparatus comprising:

a boundary detection controller capable of selecting a function to represent a modified first order difference vector of said vector space  $(Y, U, V)$ , denoted  $f_{YUV}(n)$ , wherein said function  $f_{YUV}(n)$  is calculated by convolving a low pass filter  $L_{YUV}(n)$  with a matrix  $[-1, 0, 1]$  representing a first order difference of said vector space  $(Y, U, V)$ , wherein said low pass filter  $L_{YUV}(n)$  has a cut-off frequency equal to said normalized bandwidth for signals  $Y$ ,  $U$ , and  $V$ ;

wherein said boundary detection controller is capable of operating upon said modified first order difference vector  $f_{YUV}(n)$  with a Euclidean length operator to obtain a scalar value  $\|f_{YUV}(n)\|$  that represents a value of a change in said vector space  $(Y, U, V)$  at point  $n$  and detecting a local maximum of said scalar value  $\|f_{YUV}(n)\|$ ; and

wherein said boundary detection controller is capable of determining whether said local maximum of said scalar value

22  $\|f_{UV}(n)\|$  is larger than a predetermined threshold value.

1        7. An apparatus for detecting an edge in a vector space  
2 (Y, U, V) as claimed in Claim 6, wherein said boundary detection  
3 controller is capable of selecting point n as an edge point of  
4 vector space (Y, U, V) when said local maximum of said scalar value  
5  $\|f_{UV}(n)\|$  is larger than said predetermined threshold value.

6  
7  
8  
9        8. An apparatus for detecting an edge in a vector space  
10 (Y, U, V) as claimed in Claim 7, wherein said boundary detection  
11 controller is capable of locating a boundary between two neighbor  
12 integers, n and n-1, by locating a zero crossing of a difference of  
13 a length of said modified first order difference vector for vector  
14 space (Y, U, V), denoted  $DLf_{UV}(n)$ , where said difference of a  
15 length of said modified first order difference vector is calculated  
16 by subtracting an absolute value of said scalar value  $\|f_{UV}(n-1)\|$   
17 from an absolute value of said scalar value  $\|f_{UV}(n+1)\|$ .

1           9. An apparatus for detecting an edge in a vector space  
 2   (Y, U, V) as claimed in Claim 8, wherein said boundary detection  
 3   controller is capable of locating said zero crossing of a  
 4   difference of a length of said modified first order difference  
 5   vector for vector space (Y, U, V) by calculating said location of  
 6   said boundary between said two neighbor integers, n and n-1, using  
 7   the expression:  $DL f_{YUV}(n)$

$$t_0 = \frac{|DL f_{YUV}(n-1)|}{|DL f_{YUV}(n-1)| + |DL f_{YUV}(n)|} + n - 1$$

8           where  $t_0$  represents a location of said boundary, and where n  
 9   represents a value of said integer n, and where  $|DL f_{YUV}(n-1)|$   
 10   represents an absolute value of a difference of a length of a  
 11   modified first order difference of said vector space (Y, U, V) at a  
 12   location of said integer n, and where  $|DL f_{YUV}(n-1)|$  represents an  
 13   absolute value of a difference of a length of a modified first  
 14   order difference of said vector space (Y, U, V) at a location of  
 15   said integer n-1.  
 16

1        10. An apparatus for detecting an edge in a vector space  
2        (Y, U, V) of a color image signal as set forth in Claim 6, where Y  
3        represents a luminance signal, and where U and V represent  
4        chrominance signals, and where said U and V signals have a smaller  
5        normalized bandwidth than a normalized bandwidth of said Y signal,  
6        said apparatus comprising:

7        a boundary detection controller capable of locating a  
8        luminance edge in said vector space (Y, U, V) of said color image  
9        signal and capable of locating a chrominance edge in said vector  
10       space (Y, U, V) of said color image signal;

11       wherein said boundary detection controller is capable of  
12       combining luminance edge information and chrominance edge  
13       information to determine said edge in said vector space (Y, U, V)  
14       of said color image signal.

1       11. An apparatus for detecting an edge in a vector space  
2       (Y, U, V) of a color image signal as claimed in Claim 10, wherein  
3       said boundary detection controller is capable of selecting said  
4       luminance edge as said edge in said vector space (Y, U, V) of said  
5       color image signal when said chrominance edge is located within two  
6       to four pixels of said luminance edge.

1           12. A method for detecting a boundary in a vector sequence  
2      $\vec{A}(n)$  having an arbitrary dimension, said method comprising the  
3     steps of:  
4           selecting a function to represent a modified first order  
5     difference vector of said vector sequence  $\vec{A}(n)$ , denoted  $MFD(\vec{A}(n))$ ,  
6     wherein said function is dependent upon a frequency characteristic  
7     of said vector sequence  $\vec{A}(n)$ ;  
8           operating upon said modified first order difference vector  
9      $MFD(\vec{A}(n))$  with a length operator to obtain a scalar value  
10     $\|MFD(\vec{A}(n))\|$  that represents a value of a change in said vector  
11    sequence  $\vec{A}(n)$  at point  $n$ ;  
12           detecting a local maximum of said scalar value  $\|MFD(\vec{A}(n))\|$ ;  
13    and  
14           determining whether said local maximum of said scalar value  
15     $\|MFD(\vec{A}(n))\|$  is larger than a predetermined threshold value.



1        13. A method for detecting a boundary in a vector sequence  
 2         $\vec{A}(n)$  as claimed in Claim 12, said method further comprising the  
 3        step of:

4        selecting point  $n$  as an edge point of  $\vec{A}(n)$  when said local  
 5        maximum of said scalar value  $\|MFD(\vec{A}(n))\|$  is larger than said  
 6        predetermined threshold value.

1        14. A method for detecting a boundary in a vector sequence  
 2         $\vec{A}(n)$  as claimed in Claim 12, wherein said vector sequence  $\vec{A}(n)$  is  
 3        in Euclidean space and said length operator has the form:

$$4 \quad \|\vec{A}(n)\| = \sqrt{a_1^2(n) + a_2^2(n) + \dots + a_p^2(n)}.$$

1        15. A method for detecting a boundary in a vector sequence  
 2         $\vec{A}(n)$  as claimed in Claim 13, said method further comprising the  
 3        step of:

4        locating a boundary between two neighbor integers,  $n$  and  $n-1$ ,  
 5        by locating a zero crossing of a difference of a length of said  
 6        modified first order difference vector for  $\vec{A}(n)$ , denoted  
 7         $DLMFD(\vec{A}(n))$ , where said difference of a length of said modified  
 8        first order difference vector is calculated by subtracting an

9 absolute value of said scalar value  $\|MFD(\vec{A}(n-1))\|$  from an absolute  
 10 value of said scalar value  $\|MFD(\vec{A}(n+1))\|$ .

1 16. A method for detecting a boundary in a vector sequence  
 2  $\vec{A}(n)$  as claimed in Claim 15, wherein said step of locating a zero  
 3 crossing of a difference of a length of said modified first order  
 4 difference vector for  $\vec{A}(n)$  further comprises the step of:  
 5 calculating said location of said boundary between said two  
 6 neighbor integers,  $n$  and  $n-1$ , using the expression:

$$t_0 = \frac{|DLMFD(\vec{A}(n-1))|}{|DLMFD(\vec{A}(n-1))| + |DLMFD(\vec{A}(n))|} + n - 1$$

8 where  $t_0$  represents a location of said boundary, and where  $n$   
 9 represents a value of said integer  $n$ , and where  $|DLMFD \vec{A}((n))|$   
 10 represents an absolute value of a difference of a length of a  
 11 modified first order difference of said vector sequence  $\vec{A}(n)$  at a  
 12 location of said integer  $n$ , and where  $|DLMFD \vec{A}((n-1))|$  represents an  
 13 absolute value of a difference of a length of a modified first  
 14 order difference of said vector sequence  $\vec{A}(n)$  at a location of said  
 15 integer  $n-1$ .

1        17. A method for detecting an edge in a vector space  
 2        (Y, U, V) of a color image signal as set forth in Claim 12, where Y  
 3        represents a luminance signal, and where U and V represent  
 4        chrominance signals, and where said Y, U, and V signals have an  
 5        equal normalized bandwidth, said method comprising the steps of:  
 6        selecting a function to represent a modified first order  
 7        difference vector of said vector space (Y, U, V), denoted  $f_{YUV}(n)$ ,  
 8        wherein said function  $f_{YUV}(n)$  is calculated by convolving a low pass  
 9        filter  $L_{YUV}(n)$  with a matrix  $[-1, 0, 1]$  representing a first order  
 10       difference of said vector space (Y, U, V), wherein said low pass  
 11       filter  $L_{YUV}(n)$  has a cut-off frequency equal to said normalized  
 12       bandwidth for signals Y, U, and V;  
 13       operating upon said modified first order difference vector  
 14        $f_{YUV}(n)$  with a Euclidean length operator to obtain a scalar value  
 15        $\|f_{YUV}(n)\|$  that represents a value of a change in said vector space  
 16       (Y, U, V) at point n;  
 17       detecting a local maximum of said scalar value  $\|f_{YUV}(n)\|$ ; and  
 18       determining whether said local maximum of said scalar value  
 19        $\|f_{YUV}(n)\|$  is larger than a predetermined threshold value.

1        18. A method for detecting an edge in a vector space  
2        (Y, U, V) as claimed in Claim 17, said method further comprising  
3        the step of:

4        selecting point n as an edge point of vector space (Y, U, V)  
5        when said local maximum of said scalar value  $\|f_{YU}(n)\|$  is larger  
6        than said predetermined threshold value.

1        19. A method for detecting an edge in a vector space  
2        (Y, U, V) as claimed in Claim 18, said method further comprising  
3        the step of:

4        locating a boundary between two neighbor integers, n and n-1,  
5        by locating a zero crossing of a difference of a length of said  
6        modified first order difference vector for vector space (Y, U, V),  
7        denoted  $DLf_{YU}(n)$ , where said difference of a length of said  
8        modified first order difference vector is calculated by subtracting  
9        an absolute value of said scalar value  $\|f_{YU}(n-1)\|$  from an absolute  
10       value of said scalar value  $\|f_{YU}(n+1)\|$ .

1           20. A method for detecting an edge in a vector space  
 2   (Y, U, V) as claimed in Claim 19, wherein said step of locating a  
 3   zero crossing of a difference of a length of said modified first  
 4   order difference vector for vector space (Y, U, V) further  
 5   comprises the step of:

6           calculating said location of said boundary between said two  
 7   neighbor integers,  $n$  and  $n-1$ , using the expression:  $DL f_{YUV}(n)$

$$8 \quad t_0 = \frac{|DL f_{YUV}(n-1)|}{|DL f_{YUV}(n-1)| + |DL f_{YUV}(n)|} + n - 1$$

9   where  $t_0$  represents a location of said boundary, and where  $n$   
 10   represents a value of said integer  $n$ , and where  $|DL f_{YUV}(n-1)|$   
 11   represents an absolute value of a difference of a length of a  
 12   modified first order difference of said vector space (Y, U, V) at a  
 13   location of said integer  $n$ , and where  $|DL f_{YUV}(n-1)|$  represents an  
 14   absolute value of a difference of a length of a modified first  
 15   order difference of said vector space (Y, U, V) at a location of  
 16   said integer  $n-1$ .

1           21. A method for detecting an edge in a vector space  
2   (Y, U, V) of a color image signal as set forth in Claim 17, where Y  
3   represents a luminance signal, and where U and V represent  
4   chrominance signals, and where said U and V signals have a smaller  
5   normalized bandwidth than a normalized bandwidth of said Y signal,  
6   said method comprising the steps of:

7           locating a luminance edge in said vector space (Y, U, V) of  
8   said color image signal;

9           locating a chrominance edge in said vector space (Y, U, V) of  
10   said color image signal; and

11          combining luminance edge information and chrominance edge  
12   information to determine said edge in said vector space (Y, U, V)  
13   of said color image signal.

1           22. A method for detecting an edge in a vector space  
2   (Y, U, V) of a color image signal as claimed in Claim 21, further  
3   comprising the step of:

4           selecting said luminance edge as said edge in said vector  
5   space (Y, U, V) of said color image signal when said chrominance  
6   edge is located within two to four pixels of said luminance edge.

1        23. A color image system comprising an apparatus for  
2        detecting a boundary in a vector sequence representing a signal,  
3        said apparatus comprising:

4        a boundary detection controller capable of detecting a  
5        boundary in a vector sequence  $\vec{A}(n)$  having an arbitrary dimension by  
6        selecting a function to represent a modified first order difference  
7        vector of said vector sequence  $\vec{A}(n)$ , denoted  $MFD(\vec{A}(n))$ , wherein  
8        said function is dependent upon a frequency characteristic of said  
9        vector sequence  $\vec{A}(n)$ ;

10       wherein said boundary detection controller is capable of  
11       operating upon said modified first order difference vector  
12        $MFD(\vec{A}(n))$  with a length operator to obtain a scalar value  
13        $\|MFD(\vec{A}(n))\|$  that represents a value of a change in said vector  
14       sequence  $\vec{A}(n)$  at point  $n$  and detecting a local maximum of said  
15       scalar value  $\|MFD(\vec{A}(n))\|$ ; and

16       wherein said boundary detection controller is capable of  
17       determining whether said local maximum of said scalar value  
18        $\|MFD(\vec{A}(n))\|$  is larger than a predetermined threshold value.

1        24. A color image system comprising an apparatus for  
 2        detecting a boundary in a vector sequence representing a signal as  
 3        set forth in Claim 23 wherein said boundary detection controller is  
 4        capable of selecting point  $n$  as an edge point of  $\vec{A}(n)$  when said  
 5        local maximum of said scalar value  $\|MFD(\vec{A}(n))\|$  is larger than said  
 6        predetermined threshold value.

1        25. A color image system comprising an apparatus for  
 2        detecting a boundary in a vector sequence representing a signal as  
 3        set forth in Claim 23 wherein said vector sequence  $\vec{A}(n)$  is in  
 4        Euclidean space and said length operator has the form:

$$\|\vec{A}(n)\| = \sqrt{a_1^2(n) + a_2^2(n) + \dots + a_p^2(n)}.$$

1        26. A color image system comprising an apparatus for  
 2        detecting a boundary in a vector sequence as claimed in Claim 24  
 3        wherein said boundary detection controller is capable of locating a  
 4        boundary between two neighbor integers,  $n$  and  $n-1$ , by locating a  
 5        zero crossing of a difference of a length of said modified first  
 6        order difference vector for  $\vec{A}(n)$ , denoted  $DLMFD(\vec{A}(n))$ , where said  
 7        difference of a length of said modified first order difference  
 8        vector is calculated by subtracting an absolute value of said



9 scalar value  $\|MFD(\vec{A}(n-1))\|$  from an absolute value of said scalar  
 10 value  $\|MFD(\vec{A}(n+1))\|$ .

1 27. A color image system comprising an apparatus for  
 2 detecting a boundary in a vector sequence as claimed in Claim 26  
 3 wherein said boundary detection controller is capable of locating  
 4 said zero crossing of a difference of a length of said modified  
 5 first order difference vector for  $\vec{A}(n)$  by calculating said location  
 6 of said boundary between said two neighbor integers,  $n$  and  $n-1$ ,  
 7 using the expression:

$$t_0 = \frac{|DLMFD(\vec{A}(n-1))|}{|DLMFD(\vec{A}(n-1))| + |DLMFD(\vec{A}(n))|} + n - 1$$

9 where  $t_0$  represents a location of said boundary, and where  $n$   
 10 represents a value of said integer  $n$ , and where  $|DLMFD\vec{A}((n))|$   
 11 represents an absolute value of a difference of a length of a  
 12 modified first order difference of said vector sequence  $\vec{A}(n)$  at a  
 13 location of said integer  $n$ , and where  $|DLMFD\vec{A}((n-1))|$  represents an  
 14 absolute value of a difference of a length of a modified first  
 15 order difference of said vector sequence  $\vec{A}(n)$  at a location of said  
 16 integer  $n-1$ .

1        28. A color image system comprising an apparatus for  
2 detecting an edge in a vector space (Y, U, V) of a color image  
3 signal as set forth in Claim 23, where Y represents a luminance  
4 signal, and where U and V represent chrominance signals, and where  
5 said Y, U, and V signals have an equal normalized bandwidth, said  
6 apparatus comprising:

7        a boundary detection controller capable of selecting a  
8 function to represent a modified first order difference vector of  
9 said vector space (Y, U, V), denoted  $f_{YUV}(n)$ , wherein said function  
10  $f_{YUV}(n)$  is calculated by convolving a low pass filter  $L_{YUV}(n)$  with a  
11 matrix [ -1, 0, 1 ] representing a first order difference of said  
12 vector space (Y, U, V), wherein said low pass filter  $L_{YUV}(n)$  has a  
13 cut-off frequency equal to said normalized bandwidth for signals Y,  
14 U, and V;

15        wherein said boundary detection controller is capable of  
16 operating upon said modified first order difference vector  $f_{YUV}(n)$   
17 with a Euclidean length operator to obtain a scalar value  $\|f_{YUV}(n)\|$   
18 that represents a value of a change in said vector space (Y, U, V)  
19 at point n and detecting a local maximum of said scalar value  
20  $\|f_{YUV}(n)\|$ ; and

21        wherein said boundary detection controller is capable of  
22 determining whether said local maximum of said scalar value

23  $\|f_{YUV}(n)\|$  is larger than a predetermined threshold value.

1        29. A color image system comprising an apparatus for  
 2 detecting an edge in a vector space (Y, U, V) as claimed in  
 3 Claim 28, wherein said boundary detection controller is capable of  
 4 selecting point n as an edge point of vector space (Y, U, V) when  
 5 said local maximum of said scalar value  $\|f_{YUV}(n)\|$  is larger than  
 6 said predetermined threshold value.

1        30. A color image system comprising an apparatus for  
 2 detecting an edge in a vector space (Y, U, V) as claimed in  
 3 Claim 29, wherein said boundary detection controller is capable of  
 4 locating a boundary between two neighbor integers, n and n-1, by  
 5 locating a zero crossing of a difference of a length of said  
 6 modified first order difference vector for vector space (Y, U, V),  
 7 denoted  $DLf_{YUV}(n)$ , where said difference of a length of said  
 8 modified first order difference vector is calculated by subtracting  
 9 an absolute value of said scalar value  $\|f_{YUV}(n-1)\|$  from an absolute  
 10 value of said scalar value  $\|f_{YUV}(n+1)\|$ .

1        31. A color image system comprising an apparatus for  
 2 detecting an edge in a vector space (Y, U, V) as claimed in  
 3 Claim 30, wherein said boundary detection controller is capable of  
 4 locating said zero crossing of a difference of a length of said  
 5 modified first order difference vector for vector space (Y, U, V)  
 6 by calculating said location of said boundary between said two  
 7 neighbor integers,  $n$  and  $n-1$ , using the expression:  $DL f_{YUV}(n)$

$$t_0 = \frac{|DL f_{YUV}(n-1)|}{|DL f_{YUV}(n-1)| + |DL f_{YUV}(n)|} + n - 1$$

8  
 9 where  $t_0$  represents a location of said boundary, and where  $n$   
 10 represents a value of said integer  $n$ , and where  $|DL f_{YUV}(n-1)|$   
 11 represents an absolute value of a difference of a length of a  
 12 modified first order difference of said vector space (Y, U, V) at a  
 13 location of said integer  $n$ , and where  $|DL f_{YUV}(n-1)|$  represents an  
 14 absolute value of a difference of a length of a modified first  
 15 order difference of said vector space (Y, U, V) at a location of  
 16 said integer  $n-1$ .

1        32. A color image system comprising an apparatus for  
2 detecting an edge in a vector space (Y, U, V) of a color image  
3 signal as set forth in Claim 28, where Y represents a luminance  
4 signal, and where U and V represent chrominance signals, and where  
5 said U and V signals have a smaller normalized bandwidth than a  
6 normalized bandwidth of said Y signal, said apparatus comprising:  
7        a boundary detection controller capable of locating a  
8 luminance edge in said vector space (Y, U, V) of said color image  
9 signal and capable of locating a chrominance edge in said vector  
10 space (Y, U, V) of said color image signal;  
11        wherein said boundary detection controller is capable of  
12 combining luminance edge information and chrominance edge  
13 information to determine said edge in said vector space (Y, U, V)  
14 of said color image signal.

1        33. A color image system comprising an apparatus for  
2 detecting an edge in a vector space (Y, U, V) of a color image  
3 signal as claimed in Claim 32, wherein said boundary detection  
4 controller is capable of selecting said luminance edge as said edge  
5 in said vector space (Y, U, V) of said color image signal when said  
6 chrominance edge is located within two to four pixels of said  
7 luminance edge.

1        34. Computer-executable instructions stored on a computer-  
2 readable storage medium for detecting a boundary in a vector  
3 sequence  $\vec{A}(n)$  having an arbitrary dimension, the computer-  
4 executable instructions comprising the steps of:

5        selecting a function to represent a modified first order  
6 difference vector of said vector sequence  $\vec{A}(n)$ , denoted  $MFD(\vec{A}(n))$ ,  
7 wherein said function is dependent upon a frequency characteristic  
8 of said vector sequence  $\vec{A}(n)$ ;

9        operating upon said modified first order difference vector  
10  $MFD(\vec{A}(n))$  with a length operator to obtain a scalar value  
11  $\|MFD(\vec{A}(n))\|$  that represents a value of a change in said vector  
12 sequence  $\vec{A}(n)$  at point  $n$ ;

13        detecting a local maximum of said scalar value  $\|MFD(\vec{A}(n))\|$ ;  
14 and

15        determining whether said local maximum of said scalar value  
16  $\|MFD(\vec{A}(n))\|$  is larger than a predetermined threshold value.

35. The computer-executable instructions stored on a computer-readable storage medium as claimed in Claim 34 further comprising the step of:

selecting point  $n$  as an edge point of  $\vec{A}(n)$  when said local maximum of said scalar value  $\|MFD(\vec{A}(n))\|$  is larger than said predetermined threshold value.

36. The computer-executable instructions stored on a computer-readable storage medium as claimed in Claim 34, wherein said vector sequence  $\vec{A}(n)$  is in Euclidean space and said length operator has the form:

$$\|\vec{A}(n)\| = \sqrt{a_1^2(n) + a_2^2(n) + \dots + a_p^2(n)}.$$

37. The computer-executable instructions stored on a computer-readable storage medium as claimed in Claim 35 further comprising the step of:

locating a boundary between two neighbor integers,  $n$  and  $n-1$ , by locating a zero crossing of a difference of a length of said modified first order difference vector for  $\vec{A}(n)$ , denoted  $DLMFD(\vec{A}(n))$ , where said difference of a length of said modified first order difference vector is calculated by subtracting an

9 absolute value of said scalar value  $\|MFD(\vec{A}(n-1))\|$  from an absolute  
 10 value of said scalar value  $\|MFD(\vec{A}(n+1))\|$ .

1 38. The computer-executable instructions stored on a  
 2 computer-readable storage medium as claimed in Claim 37, wherein  
 3 said step of locating a zero crossing of a difference of a length  
 4 of said modified first order difference vector for  $\vec{A}(n)$  further  
 5 comprises the step of:

6 calculating said location of said boundary between said two  
 7 neighbor integers,  $n$  and  $n-1$ , using the expression:

$$8 \quad t_0 = \frac{|DLMFD(\vec{A}(n-1))|}{|DLMFD(\vec{A}(n-1))| + |DLMFD(\vec{A}(n))|} + n - 1$$

9 where  $t_0$  represents a location of said boundary, and where  $n$   
 10 represents a value of said integer  $n$ , and where  $|DLMFD \vec{A}((n))|$   
 11 represents an absolute value of a difference of a length of a  
 12 modified first order difference of said vector sequence  $\vec{A}(n)$  at a  
 13 location of said integer  $n$ , and where  $|DLMFD \vec{A}((n-1))|$  represents an  
 14 absolute value of a difference of a length of a modified first  
 15 order difference of said vector sequence  $\vec{A}(n)$  at a location of said  
 16 integer  $n-1$ .



1        39. The computer-executable instructions stored on a  
2 computer-readable storage medium for detecting an edge in a vector  
3 space (Y, U, V) of a color image signal as set forth in Claim 34,  
4 where Y represents a luminance signal, and where U and V represent  
5 chrominance signals, and where said Y, U, and V signals have an  
6 equal normalized bandwidth, the computer-executable instructions  
7 comprising the steps of:

8        selecting a function to represent a modified first order  
9 difference vector of said vector space (Y, U, V), denoted  $f_{YUV}(n)$ ,  
10 wherein said function  $f_{YUV}(n)$  is calculated by convolving a low pass  
11 filter  $L_{YUV}(n)$  with a matrix [ -1, 0, 1 ] representing a first order  
12 difference of said vector space (Y, U, V), wherein said low pass  
13 filter  $L_{YUV}(n)$  has a cut-off frequency equal to said normalized  
14 bandwidth for signals Y, U, and V;

15        operating upon said modified first order difference vector  
16  $f_{YUV}(n)$  with a Euclidean length operator to obtain a scalar value  
17  $\|f_{YUV}(n)\|$  that represents a value of a change in said vector space  
18 (Y, U, V) at point n;

19        detecting a local maximum of said scalar value  $\|f_{YUV}(n)\|$ ; and

20        determining whether said local maximum of said scalar value  
21  $\|f_{YUV}(n)\|$  is larger than a predetermined threshold value.

1        40. The computer-executable instructions stored on a  
2 computer-readable storage medium as claimed in Claim 39 further  
3 comprising the step of:

4        selecting point  $n$  as an edge point of vector space  $(Y, U, V)$   
5 when said local maximum of said scalar value  $\|f_{YUV}(n)\|$  is larger  
6 than said predetermined threshold value.

1        41. The computer-executable instructions stored on a  
2 computer-readable storage medium as claimed in Claim 40 further  
3 comprising the step of:

4        locating a boundary between two neighbor integers,  $n$  and  $n-1$ ,  
5 by locating a zero crossing of a difference of a length of said  
6 modified first order difference vector for vector space  $(Y, U, V)$ ,  
7 denoted  $DL f_{YUV}(n)$ , where said difference of a length of said  
8 modified first order difference vector is calculated by subtracting  
9 an absolute value of said scalar value  $\|f_{YUV}(n-1)\|$  from an absolute  
10 value of said scalar value  $\|f_{YUV}(n+1)\|$ .

42. The computer-executable instructions stored on a computer-readable storage medium as claimed in Claim 41 wherein said step of locating a zero crossing of a difference of a length of said modified first order difference vector for vector space (Y, U, V) further comprises the step of:

calculating said location of said boundary between said two neighbor integers,  $n$  and  $n-1$ , using the expression:  $DL f_{YUV}(n)$

$$t_0 = \frac{|DL f_{YUV}(n-1)|}{|DL f_{YUV}(n-1)| + |DL f_{YUV}(n)|} + n - 1$$

where  $t_0$  represents a location of said boundary, and where  $n$  represents a value of said integer  $n$ , and where  $|DL f_{YUV}(n-1)|$  represents an absolute value of a difference of a length of a modified first order difference of said vector space (Y, U, V) at a location of said integer  $n$ , and where  $|DL f_{YUV}(n-1)|$  represents an absolute value of a difference of a length of a modified first order difference of said vector space (Y, U, V) at a location of said integer  $n-1$ .

1        43. The computer-executable instructions stored on a  
2 computer-readable storage medium for detecting an edge in a vector  
3 space (Y, U, V) of a color image signal as set forth in Claim 39,  
4 where Y represents a luminance signal, and where U and V represent  
5 chrominance signals, and where said U and V signals have a smaller  
6 normalized bandwidth than a normalized bandwidth of said Y signal,  
7 said computer-executable instructions comprising the steps of:

8        locating a luminance edge in said vector space (Y, U, V) of  
9 said color image signal;

10       locating a chrominance edge in said vector space (Y, U, V) of  
11 said color image signal; and

12       combining luminance edge information and chrominance edge  
13 information to determine said edge in said vector space (Y, U, V)  
14 of said color image signal.

1       44. The computer-executable instructions stored on a  
2 computer-readable storage medium for detecting an edge in a vector  
3 space (Y, U, V) of a color image signal as claimed in Claim 43,  
4 further comprising the step of:

5       selecting said luminance edge as said edge in said vector  
6 space (Y, U, V) of said color image signal when said chrominance  
7 edge is located within two to four pixels of said luminance edge.